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ABSTRACT

This paper describes the intelligent advisor system, named CODAMA, used in teaching a university-level systems analysis and design course. The paper discusses: (1) the use of CODAMA to assist students to transfer theoretical knowledge to the practical; (2) details of how CODAMA is applied in conjunction with a computer-aided software engineering tool to produce an Entity-Relationship Diagram (ERD); (3) use of the system's concept network and advance organizer; (4) CODAMA's knowledge acquisition module, which allows the recording of real ERDs; and (5) a summary of CODAMA's visual elements, including ERDs, underlining, and concept hierarchy displays. Seven figures, five of which are computer displays, illustrate the text. (KRN)

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ED 363 317

The Use of Images in Intelligent Advisor Systems

by
Marie-Michèle Boulet

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Introduction

Among the mandatory courses of the undergraduate curriculum in Computer Science at Université Laval, there is *Systems analysis and design*. Information modeling, and more specifically Entity-Relationship approach (Chen, 1976), is an important topic covered in that course.

The production of an Entity-Relationship diagram (ERD) that actually represents the access paths to data needed by an enterprise, is a very complex transfer task. As stated by Leshin, Pollock, and Reigeluth (1992): "Transfer tasks have great variation from one performance to another" (p.49); "... cannot easily be broken down into steps, because the activity varies each time the task is performed" (p.82). They also add: "Complexity is determined by the number of new principles or guidelines required to generate the desired performance" (p. 92).

The *Systems analysis and design* course has two parts. Concepts, principles, and rules, are taught during a theoretical part. Learners transfer this knowledge during a practical part; they have to resolve cases. The COnceptual DAtabase Modeling Advisor (CODAMA) was developed to further the transfer of knowledge during the practical part.

Advisor system

An intelligent advisor system is an adaptive system aimed at intervening when an individual is performing a complex transfer task (Boulet, 1992). This instructional technology takes place after the initial learning of concepts, principles, and rules. It is an environment of help utterly linked to the use of what has been learned. Users think and integrate several kinds of knowledge to find the "right" way to solve a complex problem.

An important aspect to take into account is the identification of strategies and tactics the advisor uses to provide advice, guidance, hints, explanations, and to answer questions. The main purpose is to provide an environment tailored to the user's needs and goals. An advisor system helps either to relate theory to practice, or to develop more effective problem-solving strategies, or both.

CODAMA

Students enrolled in *Systems design and analysis* course have weak knowledge of the domain and no practical experience. They draw their ERD with a CASE tool (Computer Aided Software Engineering, Figure 1). CODAMA is interfaced to that CASE tool.

Figure 1 presents the CASE tool window. The set up of CODAMA adds an option within the menu bar: the ADVISOR option. A learner produced a part of an ERD. She or he created the entities COURSE, PROGRAM, ADDRESS, STUDENT, and PROFESSOR, and the relationships ENROLLS, GIVES, and HAS. There are properties not yet associated. Some cardinalities was set. The learner can call CODAMA to make sure that this part of the ERD actually

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represents the reality of the organization.

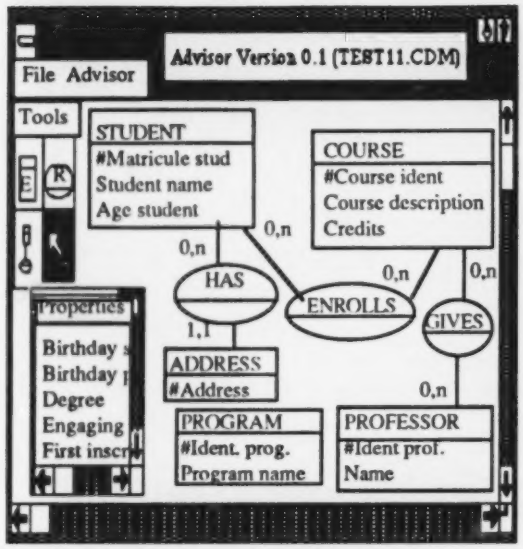

Figure 1. CASE tool window.

Figure 2 shows the menu displayed after a learner told CODAMA that she or he wanted explanations about cardinalities of the relation ENROLLS.

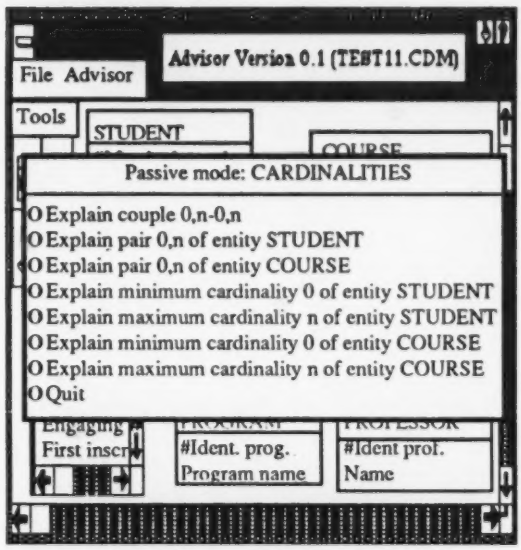
File Advisor
Advisor Version 0.1 (TEST11.CDM)
Tools
STUDENT
Passive mode: CARDINALITIES
O Explain couple 0,n-0,n
O Explain pair 0,n of entity STUDENT
O Explain pair 0,n of entity COURSE
O Explain minimum cardinality 0 of entity STUDENT
O Explain maximum cardinality n of entity STUDENT
O Explain minimum cardinality 0 of entity COURSE
O Explain maximum cardinality n of entity COURSE
O Quit
First inscr
#Ident. prog.
Program name
#Ident prof.
Name

Figure 2. Example of menu.

Suppose that the learner selects *Explain minimum cardinality 0 of the entity STUDENT*. The explanation presented at Figure 3 will be superimposed. There are underlined words. Two of them refer to prerequisites: *Entity* and *relationship*. That means an individual cannot understand what is the meaning of this explanation if she or he does not know or does not remember what is an entity or a relationship. By clicking on one of those underlined words, the learner can have the corresponding explanation (or a set of explanations because there are other underlined words within other explanations). This access to prerequisites was set to help recalling one or another concept in the short term memory.

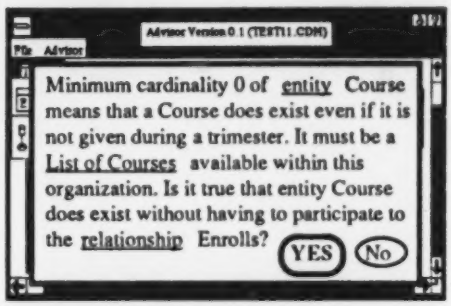
Minimum cardinality 0 of entity Course means that a Course does exist even if it is not given during a trimester. It must be a List of Courses available within this organization. Is it true that entity Course does exist without having to participate to the relationship Enrolls?
YES
No

Figure 3. CODAMA's answer.

The learner can also see and use a network. A part of the network is presented at Figure 4.

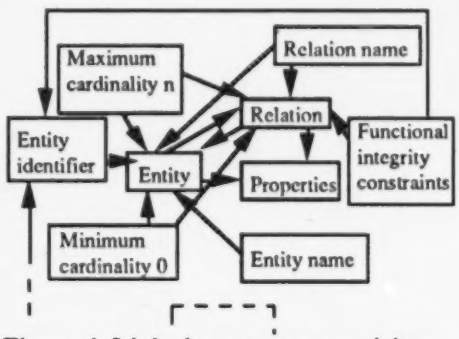

Figure 4. Links between prerequisites.

A network can be used in many ways. A learner can ask for the network showing prerequisites for a given concept. She or he can use it to have a given explanation by clicking on one or another

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box. Another learner can ask which box corresponds to a certain question she or he asked CODAMA. She or he can also see which box corresponds to a particular mistake that the advisor detected. Doing so, she or he will also see what are the related prerequisites.

The third underlined group of words, i.e., *List of Courses* (Figure 3), refers to a hypothesis that CODAMA makes. If the student clicks on those words, CODAMA will present a list that is supposed to exist within the organization. Note that, for some other cases, CODAMA will present hypothetical forms such as a bill. This allows the student to relate her or his perception of the reality to the entity-relationship formalism. That is what an analyst MUST do during all her or his professional life, i.e., verify repeatedly whether what he or she models is the real thing.

An advance organizer (Ausubel, 1960) may be used before starting the process of elaborating an ERD. First, CODAMA displays a complete and real ERD obtained from experts. A knowledge acquisition module allows the collecting of those real ERDs. It is described in the next section of this paper. The ERD being displayed, the organizer simulates the elaboration of this ERD. The simulation is made in accordance with a hierarchy of prerequisites

When the advance organizer module intervenes after a user begins to elaborate an ERD, it takes into account the user's cognitive structure. There is a continuous collection of data that is invisible to the learner: questions asked and errors made are categorized and recorded.

Suppose that a learner used several menus but did not use keywords. CODAMA will fit its interventions. It could produce the advice presented at Figure 5.

Following this advice, CODAMA begins the simulation of the elaboration of an ERD. It will first refer to the highest element of the hierarchy consulted. That corresponds to where the learner is or wants to be. CODAMA will after go down the hierarchy to determine the content of its next explanations. In other words, it will present the prerequisites. When the bottom of the hierarchy is reached, CODAMA will go back all the hierarchy. In the particular case illustrated at Figure 5, CODAMA's simulation will put emphasis more on explanations related to fundamental concepts and principles than on the modeling technique.

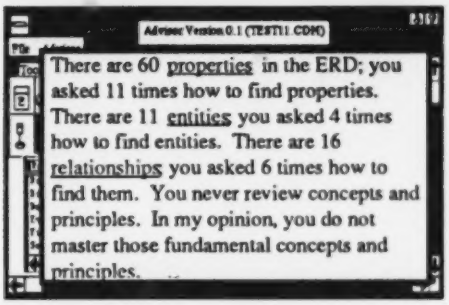
There are 60 properties in the ERD; you asked 11 times how to find properties. There are 11 entities you asked 4 times how to find entities. There are 16 relationships you asked 6 times how to find them. You never review concepts and principles. In my opinion, you do not master those fundamental concepts and principles.

Figure 5 Example of advice.

Knowledge acquisition module

The knowledge acquisition module allows the recording of real ERDs. To acquire those examples, experts firstly draw the ERD using the CASE tool (Figure 1). CODAMA's knowledge acquisition module is then made active. It begins by asking the expert to describe the organizational context. A specific part of the ERD is then explained. An example is presented at Figure 6.

In the following example, what an expert described to explain a minimum cardinality 1 is placed between <>.

Given a <manufacture of furniture>. Its clients are <retail shops, persons, and organizations>. This enterprise <makes to order>. When it receives an <order>, the following form is used (Figure 7):

Entities <Order> and <Furniture> and relationship <Concerns> can be identified. An <Order> begins to exist in the memory of the organization when it <Concerns> at least one <Furniture>. That means a minimum cardinality of 1 is necessary.

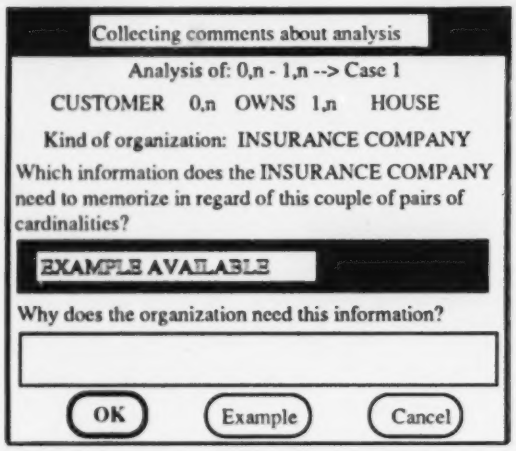
Collecting comments about analysis
Analysis of: 0,n - 1,n --> Case 1
CUSTOMER 0,n OWNS 1,n HOUSE
Kind of organization: INSURANCE COMPANY
Which information does the INSURANCE COMPANY need to memorize in regard of this couple of pairs of cardinalities?
EXAMPLE AVAILABLE
Why does the organization need this information?
OK
Example
Cancel

Figure 6 Example of expert's comments

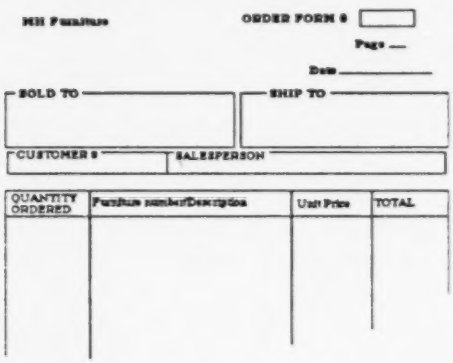

Figure 7. Order form.

Summary of visual elements

The CODAMA's visual elements are the following:

ERD or part of an ERD is used. Each ERD refers to several kinds of documents used within the organization (such as forms, memos, lists).

Underlined words allow the recall of prerequisites in the short term memory. Learners use the mouse to select the prerequisites to be explained.

A network of prerequisites is presented in different ways. A learner can ask to visualize the explanations related to a particular prerequisite (such as how to find the name of entities). In that case, only a part of the network is presented. Another learner may want to know where she or he is within the network. CODAMA will take into account her or his requests for explanations or identification of mistakes.

A hierarchy of prerequisites can be seen. A learner can ask to which objective a specific question relates. CODAMA will show where she or he is within the hierarchy. Another learner can ask to which objective a particular error relates, i.e., which objective is not mastered. Here again, CODAMA will show the hierarchy to situate the error. In the same way, CODAMA can answer a learner asking what are the prerequisites of a concept or a principle, or where she or he is within the hierarchy.

Conclusion

Students, when asked what is an entity or a relationship, use less textbook like explanations and more examples. So, the advisor favors the transfer of knowledge.

At the end of their curriculum, students have a training period within an organization. More than sixty percent asked to use CODAMA during this training period.

We think that a part of this success is due to the various uses of images and visual cues. They have to be carefully thought and planned during the development life cycle. They are an important part of the advisor's strategy of intervention.

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